CURRENT LITERATURE

NOTES FOR STUDENTS

General biology of rusts.—KLEBAHN[1] has published a series of observations on rust fungi made during 1912 and 1913. The report covers three phases of work: a study of the factors which bring about the termination of the rest period in teleutospores, cultural work, and some observations on the mallow rust in relation to ERIKSSON'S mycoplasma theory.

In order to study the factors influencing the termination of the rest period in teleutospores, the author subjected teleutosporic material of *Puccinia graminis*, *P. Phragmites*, and *P. Magnusiana* to various treatments such as exposure to low temperatures, alternate wetting and drying, and continuous immersion in water. Apparently the changes in the spore which make germination possible depend not so much upon exposure to low temperatures as upon the action of moisture. Spores suspended in a dry shed and subject only to atmospheric moisture failed to germinate. Alternate wetting and drying is most potent in shortening the rest period; spores subjected to such treatment, even at room temperature, germinated in January two to three months before the usual time. Even continuous immersions with frequent changes of water somewhat shortens the rest period, although occasional drying seems to be essential to produce any marked effect.

The second part of the paper has already been noted.[2] In the third section some experiments and observations on the mallow rust furnish a basis for discussion of ERIKSSON'S views on the means of distribution of this fungus. ERICKSSON'S main contention[3] is that the fungus is distributed in the mycoplasma state with the seed, and manifests itself by a general outbreak over the entire surface of the infected plant when it is about three months old. These contentions are not borne out by the experiments of KLEBAHN, who finds that different groups of plants grown from the same lot of seed become infected at different times, and the outbreak does not involve the whole plant at once. The sori are at first scattered and few, as if originating from local infections. To the conidia-like segments sometimes produced by the promycelium of this rust ERIKSSON attributes the special function of giving rise to the mycoplasma

[1] KLEBAHN, H., Kulturversuche mit Rostpilzen. Zeitschr. Pflanzenkrank **24**:1–32. *fig. 1.* 1914; also Beobachtungen über Pleophagie und über Teleutosporenkeimung bei Rostpilzen. Jahresb. Verein Angew. Botanik **11**:55–59. 1913 (a short statement of the main facts in the foregoing paper).

[2] Rev. BOT. GAZ. **60**:245. 1915.

[3] *Ibid.* **54**:431. 1912.

in the plants infected by these spores. DIETEL[4] has already shown that the production of "conidia" by the promycelium does not indicate a functional differentiation of the teleutospores, but is dependent on external conditions. In this matter KLEBAHN agrees with DIETEL, but the two investigators differ somewhat as to the factors which determine the segmentation of the germ tubes. KLEBAHN finds that spores germinating within a liquid medium produce, in place of normal mycelia, germ tubes which may become segmented or not. The number of segments produced is always four, and under some conditions the "conidia" produce sporidia. Teleutospores germinating in contact with air always produce promycelia and sporidia. DIETEL attributes the production of segmented germ tubes to a scanty moisture supply in the substratum. KLEBAHN infected a number of leaves of hollyhock with cultures of teleutospores which were producing "conidia." The groups of sori originating from these infections were cut out of the leaves which were kept under observation during the rest of the season. According to ERIKSSON, these leaves should have contained mycoplasma which should later have given rise to a general outbreak of rust on the leaves. KLEBAHN found, however, that the leaves from which the sori had been removed remained free from infection.

The mycoplasma theory is attacked from another standpoint by HAASE-BESSEL,[5] who finds in and about mature rust pustules of secondary origin on leaves of *Althaea rosea* attacked by mallow rust mycelial structures resembling the promycelium described by ERIKSSON. These structures on account of their delicate walls have the appearance of naked masses of protoplasm which conform to the shape of the intercellular spaces which they occupy. A study of their origin shows that they are the outgrowths of older hyphae at the base of the rust pustules. The author attributes to them the function of distributing the mycelium through the leaf. Since these structures, conforming in every way to ERIKSSON's promycelia, are observed originating from the mycelium of mature pustules of undoubted secondary origin, the author argues that the similar structures of ERIKSSON may be explained without the aid of the mycoplasma theory. To this conclusion ERIKSSON would object, as to the other similar arguments, that the mycoplasma does not occur in connection with rust infections originating from spores. Thus the elusive mycoplasma again escapes annihilation.

A cytological study supplemented by field observations has enabled OLIVE[6] to explain some apparently anomalous phenomena in the sequence of spore forms and the formation of aecidia in certain rusts with perennial mycelia.

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[4] Rev. BOT. GAZ. **56**:163. 1913.

[5] HAASE-BESSEL, G., Zur Erikssonchen Mycoplasmatheorie. Ber. Deutsch. Bot. Gesells. **32**:393–403. *pl. 9.* 1914.

[6] OLIVE, E. W., Intermingling of perennial sporophytic and gametophytic generations in *Puccinia Podophylli*, *P. obtegens*, and *Uromyces Glycyrrhizae*. Ann. Mycol. **11**:298–311. *pl. 1.* 1913.

The forms investigated are *Puccinia Podophylli*, *P. suaveolens*, and *Uromyces Glycyrrhizae*. Early in spring *Puccinia Podophylli* usually produces teleutospores on the bud sheaths at the base of the stems of the host plant (*Podophyllum peltatum*). These teleutospores are produced before any other spore forms and also before the plants are fully developed. Sometimes, according to OLIVE, traces of aecidia also, but no spermagonia, are found on the bud sheaths. Later, spermagonia and aecidia develop abundantly on the leaves. These aecidia have been shown by SHARP[7] to arise from a binucleate mycelium. Teleutospores are produced on the leaves in late summer. OLIVE finds that the teleutospores on the bud sheaths and the aecidia, both here and on the leaves, arise from a perennial sporophytic (binucleate) mycelium which extends throughout the plant. Intermingled with the sporophytic mycelium is a perennial gametophytic (uninucleate) mycelium which gives rise to spermagonia and to incepts of aecidia which, however, are soon invaded by the sporophytic mycelium whose hyphae give rise to basal cells and rows of binucleate aecidiospores. The mycelia of these two generations are generally commingled throughout the plant, but in the young parts the gametophytic mycelium is somewhat in advance of the sporophytic. Besides these perennial forms, local binucleate mycelia, originating from aecidiospores and giving rise to teleutospores, occur on the leaves. In *Puccinia suaveolens* on the Canada thistle and in *Uromyces Glycyrrhizae* on *Glycyrrhiza lepidota* three conditions of mycelial distribution have been observed by the author: first, perennial gametophytic mycelium giving rise to spermagonia and perennial sporophytic mycelium giving rise to secondary uredospores and to teleutospores are commingled throughout the same plant; second, perennial sporophytic mycelium giving rise to secondary uredospores and to teleutospores occurs alone; third, annual local mycelium occurs which also produces uredospores and teleutospores, but the sori in which these are produced are rarely confluent like those of the perennial mycelium. Perennial gametophytic mycelium alone or local colonies of gametophytic mycelium have not been observed.

In all these cases no spore forms resulting from gametophytic cell fusions have been found. The aecidiospores of *Puccinia Podophylli* and the uredospores of *P. suaveolens* and *Uromyces Glycyrrhizae* are all regarded as secondary in nature. They arise apogamously, solely from sporophytic mycelia. The author has not observed aecidiospores nor primary uredospores arising as the result of fusions between gametes in these forms.

DAWSON[8] has studied the distribution of the mycelium of *Puccinia fusca* and *Aecidium leucospermum* in the rhizomes, buds, and leaves of *Anemone nemorosa*. The mycelium of these fungi is found in the rhizomes and buds of the

[7] SHARP, L. W., Nuclear phenomena in *Puccinia Podophylli*. BOT. GAZ. **51**:463–464. 1911.

[8] DAWSON, W. J., Über das Mycel des *Aecidium leucospermum* und der *Puccinia fusca*. Zeitschr. Pflanzenkrank. **23**:129–137. 1913.

infected plants, but its distribution may be more or less local. Frequently one section of the rhizome with its buds is infected, while the adjacent sections remain free from the fungus. All the leaves arising from the infected sections become infected. Experiments like those reported by TISCHLER[9] for *Uromyces Pisi*, to determine if the plants could outgrow the fungus, were not conducted. The mycelium is found in all the tissues except the phloem and xylem; in the buds even the cells of the dermatogen are invaded. In this respect the distribution of the mycelium in the growing points agrees with that of *Uromyces Pisi* in *Euphorbia Cyparissias* as observed by DE BARY and TISCHLER. There is apparently a marked difference, however, in the behavior of the mycelium of these two fungi in the embryonic tissue. TISCHLER observed the interesting fact that no haustoria were formed by the hyphae of *U. Pisi* in the strictly meristematic cells, while DAWSON states that haustoria are formed in all parts of the plant containing mycelium, even "close" to the growing point. Unfortunately neither the description nor the imperfect sketches make this physiologically important point entirely clear.

TISCHLER[9] has published a further contribution to his interesting studies on the relation between *Uromyces Pisi* and its aecidial host *Euphorbia Cyparissias*. In his former account the fact was brought out that under certain conditions the upper portions of infected shoots of this plant might produce normal leaves to all appearances free from the fungus. In such cases it was found that the growing point had became emancipated from the fungus, which was thereafter unable again to invade the strictly embryonic tissues. The behavior of these shoots is now contrasted with that of shoots from dormant buds of infected rhizomes. Such shoots produce only typically deformed leaves characteristic of plants infected by the fungus. If, however, the infected rhizomes are kept permanently in a vegetative state by pruning or other means, the new shoots produced show no external signs of the fungus and bear only normal leaves. If infected plants, which as a result of such treatment have produced only normal leaves for a season, are allowed to remain dormant for a time, only infected shoots grow out from the dormant buds. It appears, therefore, that buds that develop on the rhizome while the plant is kept continually in a vegetative state, and which start into growth without having undergone a distinct period of rest, are not subject to the formative influence of the fungus; but buds which have undergone a period of dormancy become subject to such influence and produce only deformed leaves. Nevertheless, the apparently sound shoots are not free from the fungus, for the mycelium is found in all parts except the meristematic tissue of the growing point; this it is entirely unable to invade in shoots which have once become emancipated.

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[9] Rev. BOT. GAZ. **56**:161. 1913.

[10] TISCHLER, G., Über latente Krankheitsphasen nach *Uromyces*-Infektion bei *Euphorbia Cyparissias*. Bot. Jahrb. **50**:95–110. *figs. 6*. 1914.

Wherein lie the causes of this peculiar difference of behavior of the two kinds of buds the author was unable thus far to determine.

HAAK[11] has published a somewhat lengthy account of a series of general observations and experiments on the biology of *Peridermium Pini*, and particularly on the question of the propagation of this rust by aecidiospores. From the observation that no probable telial host is coextensive in its distribution with *Pinus sylvestris* and its blister rust (*Peridermium Pini*), and also because of the failure up to this time to find the telial phase of this rust, HAAK infers the likelihood that this fungus is propagated on the pine by aecidiospores. This assumption contains in itself nothing anomalous, since several rusts with repeated aecidial generations are known. The experiments by which it is endeavored to substantiate this assumption furnish only probable evidence. Cultures on sound trees having failed to give satisfactory results (out of 72 trees with about 200 sowings only one infection resulted), subsequent cultures were made only on trees which showed the presence of *Peridermium*. The diseased branches were removed and numerous small twigs were infected in wounds. Although the number of *Peridermium* cankers resulting from these infections was small compared with the number of infected twigs, the proportion of diseased twigs to sound twigs was much greater on the infected branches than on the uninfected ones. The circumstantial evidence, therefore, seems to indicate that this fungus can be propagated on the pine by means of aecidiospores. A histological examination to determine whether the mycelium under the aecidia was sporophytic or gametophytic was not made. Two further points of interest in the biology of this fungus are brought out by the author. First, natural infections take place only in green twigs still bearing needles; no infections occur in older twigs. Even old cankers on trunks and large branches, where the origin has not been completely obliterated, can be traced to infections of small twigs from which the disease has gradually spread. Secondly, when a tree is once infected, the disease spreads by new infections to other branches during succeeding years. This fact is in accord with the theory that the aecidiospores are capable of reinfecting the pine.

BAUDYS[12] adds a contribution to the question of the maintainance of rusts by means of wintering uredospores or mycelium. The observations were made during the winters of 1910–1911 and 1911–1912 in Bohemia, where the temperature ranged as low as −16° C. and −21° C. respectively during the two seasons. From 60 to 100 per cent of the uredospores in the winter sori of *Puccinia glumarum* and *P. dispersa* on rye, and *P. bromina* on *Bromus sterilis* were found to retain their capacity for germination throughout the winter. These rusts

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[11] HAAK, ———., Der Keinzopf *Peridermium Pini* (Willd.) Kleb. Zeitschr. Forst u. Jagdwesen **46**:3–46. *pls. 2.* 1914.

[12] BAUDYS, E., Ein Beitrag zur Überwinterung der Rostpilze durch *Uredo*. Ann. Mycol. **11**:30–43. 1913.

were kept under observation from early autumn until the general outbreak of rust the following spring. It was found also that young undeveloped sori in the leaves continued to develop when temperature conditions were favorable. The mycelium in the neighborhood of the sori was found to be alive. Uredospores of *Puccinia dispersa* retained their germinative power as long as 100 days, although the percentage of viable spores decreased during that time. The uredospores of a number of other rusts were found to be capable of germinating during the winter, but observations on these forms were not carried through the entire season. Uredospores of *Puccinia simplex* on *Hordeum murinum* germinated on December 29; those of *Uromyces Anthyllidis* on *Anthyllis vulneraria* on December 11; those of *U. Ervi* on *Vicia hirsuta* on January 29; and those of *Puccinia Lolii* on *Lolium perenne* on March 5.

STAKMAN[13] has investigated for the conditions of Minnesota some of the problems relating to the specialization of physiological races of the cereal rusts and the resistance of different varieties of wheat to rusts. The results are in general in accord with the observations of other investigators, and serve to emphasize the fact that particular strains of *Puccinia graminis* inhabiting the common cereals are more or less specifically adapted to particular species, but that this adaptation is not entirely rigid. Of all the forms, that on the oat is most strictly specialized. The forms on wheat, barley, and rye migrate more or less readily from one cereal to another. Treatment of the plants with anaesthetics makes them more susceptible to infection. Resistance to rust seems to depend more on the nature of the variety than upon any external factors to which the plant is subjected. Certain phenomena, such as length of the incubation period of the rust within the plant, size of pustules and of spores, seem to be correlated with the degree of resistance of the host. The observations of MARSHALL WARD that in resistant plants the rust mycelium usually killed small infected areas of the leaves and thereby brought about its own destruction was confirmed.

Miss SAHLI[14] has continued the investigations begun by FISCHER[15] on the susceptibility of hybrids and chimaeras of mixed immune and susceptible parentage to the attacks of fungi to which one parent is susceptible. A number of cultures with teleutospores of *Gymnosporangium Sabinae*, *G. clavariaeforme*, *G. confusum*, and *G. tremelloides*, all inhabiting species of *Crataegus*, *Sorbus*, and *Mespilus*, were made on hybrids and chimaeras of these plants. In general, there appears to be no constant relation between the state of immunity of the parents and that of the hybrids or chimaeras. For the details concerning each case, the paper itself should be consulted.—H. HASSELBRING.

[13] STAKMAN, E. C., A study in cereal rusts. Physiological races. Tech. Bull. **138**. Agric. Exp. Sta. Univ. Minn. pp. 56. *pls. 9*. 1914.

[14] SAHLI, GERTRUDE, Die Empfünglichkeit von Pomaceen-Bastarden und Chimären für Gymnosporangien. Mycol. Centralbl. **3**:10–11. 1913.

[15] Rev. BOT. GAZ. **56**:163. 1913.